A STATOR RESISTANCE ESTIMATION OF INDUCTION MOTOR USING FUZZY LOGIC

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A thesis submitted in partial fulfillment of the

requirements for the awarded of the Degree of Bachelor of Electrical &

Electronics Engineering

Faculty of Electrical & Electronics Engineering

University Malaysia Pahang

NOVEMBER, 2010

I declare that this thesis entitled "A STATOR RESISTANCE ESTIMATION OF INDUCTION MOTOR USING FUZZY LOGIC*"* is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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Date	: 29 NOVEMBER 2010

To my beloved mother and father and those who have guided and inspired me throughout my journey of learning.

ACKNOWLEDGEMENT

This project would not have been possible without considerable guidance and support. So, I would like to acknowledge those who have enabled me to complete this project.

Firstly I would like to thank to my project supervisor, Mrs. Norazila Bt Jaalam for providing the guideline with continues advice and feedback throughout the duration of finishing this project.

Secondly I would also like to thank for all other University Malaysia Pahang staff members that I may have called upon for assistance since the genesis of this project. Their opinions and suggestions have helped me in realizing this project. Also not to be forgotten, I would like to thank for all my friends with the support, valuable opinion and sharing ideas during the progress of this project.

Finally, I would like to thank to my family for their understanding, encouragement and support, towards the compilation of my project. Unfortunately, it is not possible to list all of them in this limited space. Thank you so much.

ABSTRACT

During the operation of induction motor, stator resistance changes incessantly with the temperature of the working machine. This situation may cause an error in rotor resistance estimation of the same magnitude and will produce an error between the actual and estimated motor torque which can leads to motor breakdown in worst cases. Therefore, this project will propose an approach to estimate stator resistance of induction motor using fuzzy logic. Then, a correction will be making to ensure the stabilization of the system.

Generally, this project can be divided into three parts which are design the induction motor by using the mathematical equation, design Fuzzy Logic estimator to estimate the value of stator resistance R_S, and make the correction of stator resistance, R_S. The MATLAB simulink is used in order to design the induction motor. Secondly, Fuzzy Logic Toolbox is used to design fuzzy logic estimator and finally the correction of R_S is make.

ABSTRAK

Semasa operasi motor induksi, perubahan rintangan stator berkadar terus dengan suhu. Situasi ini boleh menyebabkan gangguan bagi menganggar jarak dan arah bagi rotor dan akan menghasilkan kesilapan antara kekuatan motor sebenar yang boleh menyebabkan kerosakan motor dalam keadaan amat teruk. Oleh itu, projek ini akan mencadangkan suatu pendekatan untuk meramal ketahanan stator motor induksi menggunakan Logic Fuzzy. Kemudian, pembetulan akan dilakukan untuk memastikan kestabilan sistem.

Umumnya, projek ini boleh dibahagikan kepada tiga bahagian iaitu merekabentuk motor induksi dengan menggunakan persamaan, mencipta anggaran Logik Fuzzy untuk menganggarkan nilai rintangan stator Rs, dan membuat pembetulan bagi stator, Rs. Perisian MATLAB digunakan untuk merekacipta motor induksi. Kedua, Fuzzy Logic Toolbox digunakan untuk mereka anggaran logik fuzzy dan akhirnya pembetulan Rs dibuat.

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LIST OF SYMBOLS

V_{ds}	-	*direct* component of the stator voltage vector
V_{qs}	-	*quadrature* component of the stator voltage vector
I_{ds}	-	*direct* component of the stator current vector
I_{qs}	-	*quadrature* component of the stator current vector
λ_{ds}	-	*direct* component of the rotor flux vector
λ_{qs}	-	*quadrature* component of the rotor flux vector
L_s	-	Stator inductance
L_r	-	Rotor inductance
L_m	-	Mutual inductance
R_s	-	Resistance of a stator phase winding
R_r	-	Resistance of a rotor phase winding
T_s	-	Stator time constant
T_r	-	Rotor time constant
σ	-	$1-\frac{L_m^2}{(L_s L_r)}$ total leakage factor
ω_r	-	Rotor electrical angular velocity

LIST OF ABBREVIATIONS

GUI	Graphical User Interface
CCE	Change Current Error
CE	Current Error
RC	Resistance Change
NL	Negative Large
NM	Negative Medium
NS	Negative Small
Z	Zero
PS	Positive Small
PM	Positive Medium
PL	Positive Large

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CHAPTER 1

INTRODUCTION

1.1 Background

Asynchronous motors, particularly the squirrel-cage induction motor, enjoy several inherent advantages like simplicity, reliability, low cost and virtually maintenance-free electrical drives. These facts are due to the induction motor advantages over the rest of motors. The main advantage is that induction motors do not require an electrical connection between stationary and brushes. Induction motor also has low weight and inertia, high efficiency and high overload capability.

However, for high dynamic performance industrial applications, their control remains a challenging problem because they exhibit significant non-linearity and many of the parameters, mainly the stator resistance, vary with the operating conditions such as the temperature.

The problem is overcome by adding another on-line estimation for R_s to the system using a fuzzy non-linear observer, giving the indirect vector control system, total immunity to resistance variations. The stator resistance identifier uses the error between a discrete estimate of stator current and the measured stator current, to map the change in stator resistance, using a fuzzy non-linear mapping.

The proposed fuzzy logic estimator, which is designed to estimate the change in stator resistance during the drive, is in operation. A fuzzy logic real time estimator is used as the stator resistance observer, to eliminate the error in rotor resistance estimation.

Once the stator resistance is estimated, the new of stator resistance Rs is added to eliminate the error in rotor resistance and give same magnitude and same torque to the induction motor.

1.2 Problem Statement

A mismatch between the real rotor flux and the estimated rotor flux, leads to error between the real motor torque and the estimated torque and hence poor dynamic performance. The error in stator resistance R_s, leads to errors in rotor resistance R_r.

1.3 Objectives of the project

The vital objective of this project is to estimate stator resistance R_s in induction motor by using fuzzy logic estimator to eliminate an error of rotor resistance R_r estimation in order to get the right magnitude and torque during the operation of induction motor.

1.4 Scopes of the project

The scopes of the project are:

- Design an estimated of induction motor.
- Design Fuzzy Logic estimator to estimate stator resistance R_s.
- Make the correction of stator resistance R_s.

1.5 Thesis outline

This thesis contains five chapters. Which are introduction, literature review, methodology, result and discussion, conclusion and recommendations.

Chapter 1 is explaining about the background, objectives, and scopes of the project and overview of the whole chapter. This chapter explains more about the outcomes and introduction about this project.

Chapter II provides a literature review on stator resistance overview in general. Other than that, this chapter also discusses about the methods used today to estimate stator resistances.

Chapter III focuses on the methods that are used for this project including flow chart, and circuit design of the system. Other than that, it also discusses about software used for this project. The part of software can be divided into three parts which are designing estimated induction motor, design fuzzy logic estimator, and make the correction of stator resistance.

Chapter IV discusses about the result obtained from the simulation. The results obtained are explained more detail part by part. The explanation includes equation, graph and theory of the whole project while Chapter V covers the conclusion, problems encountered and future recommendations about this project.

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CHAPTER II

LITERATURE REVIEW

2.1 Introduction

This chapter presents an overview of stator resistance R_s estimation of induction motor, and types of method that used for estimate the value of the stator resistance in induction motor.

2.2 Stator Resistance Estimation Overview

The stator resistance changes due to the temperature variations and stator frequency variation that deteriorate the drive performance by introducing errors in the estimated magnitude and position of the stator flux vector.

2.3 Types of Stator Resistance Estimation

Direct torque control (DTC) of induction machines presents a good tracking for both electromagnetic torqueand stator flux [1]. This control scheme, shown in Figure 2.10, depends only on stator measurements.

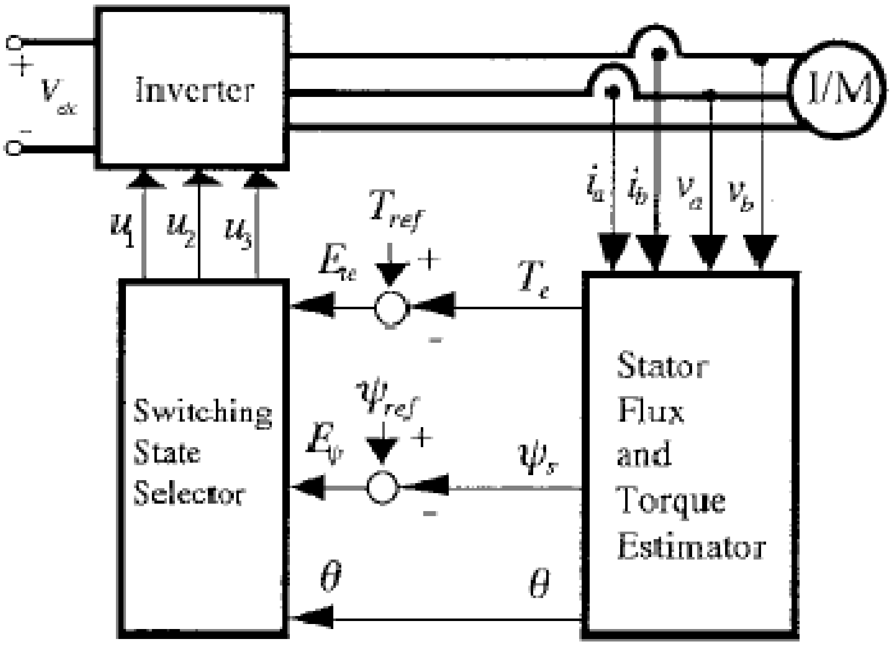

Figure 2.1 Direct Torque Control (DTC) [1]

Here [1] an artificial neural network (ANN) is used to accomplish tuning of the stator resistance of an induction motor. The parallel recursive prediction error and back propagation training algorithms were used in training the neural network for the simulation and experimental results, respectively. The neural network used to tune the stator resistance was trained on-line, making the DTC strategy more robust and accurate. Simulation results are presented for three different neural-network configurations showing the efficiency of the tuning process.[1]

This paper [2] describes a Quassi-Fuzzy method of online stator resistance estimation of an induction motor, where the resistance value is derived from stator winding temperature estimation as a function of stator current and frequency through an approximate dynamic thermal model of the machine. The estimator has been designed and iterated by simulation study and then implemented by a digital signal processor on a 5 horse power stator flux oriented direct vector controlled drive. [2]

In [3] presents application of Adaptive Neuro-fuzzy inference system (ANFIS) into a squirrel cage induction machine towards modeling, control and estimation. This paper contributes (i) Development of a simple and more realistic model of the induction motor. Using ANFIS, the parameter sets of the motor model are estimated. The simplified model contains eleven estimated parameters. The identified model can be utilized for electric drives. (ii) Speed, torque and flux control using direct torque control (DTC) algorithm with ANFIS (iii) Design of Estimator through ANFIS which estimates the stator resistance with reference to the temperature when the DTC algorithm is involved. Better estimation of stator resistance results in the improvements in induction motor performance using DTC thereby facilitating torque ripple minimization. The values of stator voltage (V_s), stator current (I_s) and rotor angular velocity (ω_r) are taken. [3]

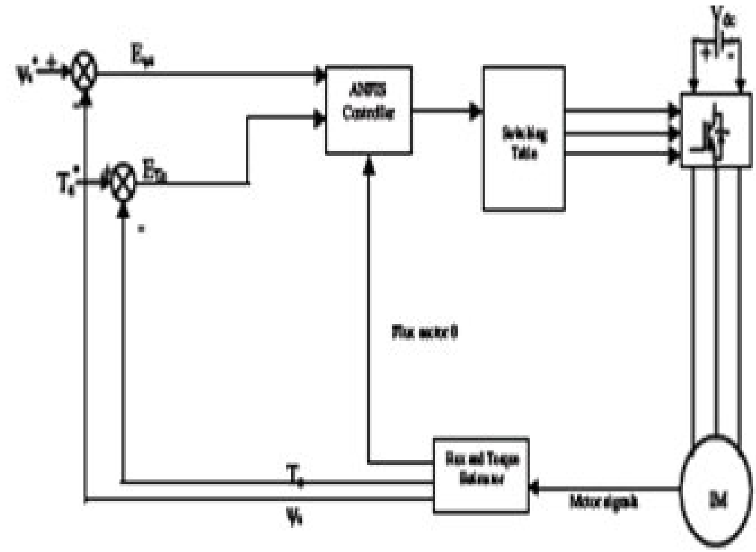

Figure 2.2 Adaptive direct torque neuro fuzzy control [4]

Figure 2.2 shows the block diagram of direct torque nuero fuzzy control (DTNFC) of induction motor. Torque and stator flux are estimated mathematically from the motor signals. Adaptive Neuro-fuzzy inference system (ANFIS) is used as controller to which the torque and flux errors along with position of stator flux are given as inputs and from which inverter-switching states are estimated.

A ninth-order estimation algorithm is designed which provides on-line exponentially convergent estimates of both rotor and stator resistance for induction motors, when persistency of excitation conditions are satisfied and the stator currents integrals are bounded, on the basis of rotor speed, stator voltages, and stator currents measurements. Rotor flux is also asymptotically recovered. The proposed estimation scheme is intended to improve performance and efficiency of currently available induction motor control algorithms. [4]

A fuzzy logic real time estimator is used as the stator resistance observer, to eliminate the error in rotor resistance estimation. The performance of the induction motor drive with the above rotor and stator resistance estimators is investigated for torque and flux responses, to analyze the effects of stator resistance observer on rotor resistance identification, for variations in the stator and rotor resistances from their nominal values. Both these resistances are estimated experimentally, in a vector controlled induction motor drive and found to give accurate estimates. [5]

A stator and rotor resistance estimation technique for the purpose of stator winding and rotor conductor temperature monitoring is presented in this paper. [6] The proposed estimation scheme is a two-step procedure based on the voltage, current, and speed measurements. The first step is to estimate the rotor resistance and rotor flux linkage simultaneously based on a Model Reference Adaptive System (MRAS) structure that is independent of R_s. In the second step, the stator resistance is updated based on the estimated rotor flux linkage using the q-axis stator voltage equation in the synchronous reference frame. [6]

A novel motor stator estimation scheme for the purpose of monitoring the temperature in steady state is proposed in this paper [7] and the feasibility of wavelet network-based estimation of the stator resistance. The occurring instants of the signal change can be identified by the multi-scale representation of the signal. The improved least squares algorithm transform is used to fulfill the network structure initialization and parameter identification. The corresponding temperature is calculated according to the principle that the metal resistance depends on its temperature. [7]

The proposed scheme in this paper [8] is based on both a rotor resistance estimation technique and a lumped thermal model of an induction machine.

Temperature estimation based on a parameter model that determines the rotor resistance is quite accurate under rated load conditions. Therefore, rotor temperature of a slightly loaded induction machine may be better approximated by a thermal model which evaluates the losses of the induction machine. [8]

This paper [9] studies the influence of the stator resistance variation on MRAS speed estimation. It has been shown that when a motor is running at high speed, the effect of error in stator resistance is usually quite negligible. But as the frequency approaches zero, this becomes more serious because the voltage drop on stator resistance becomes relatively larger as the frequency decreases. Under this reference scheme, one component of flux can be decoupled from the corrupting effects of the stator resistance and the other quadrature component can provide a near-instantaneous estimate of the stator resistance.